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(54) Method of relieving edge stress in a running web

(57) Edge-tears in a wide running web are minimized by guiding the web with rollers each having a cylindrical central portion (C) and tapered ends (12) with the junctions (14) between the cylindrical portion and the tapered ends being rounded and located inboard of the edges of the web being run. The taper angle is selected so that substantially all contact between the web and the roller is lost within a very short distance outboard of those junctions, whereby the tension in the running web is essentially zero at the web edges.

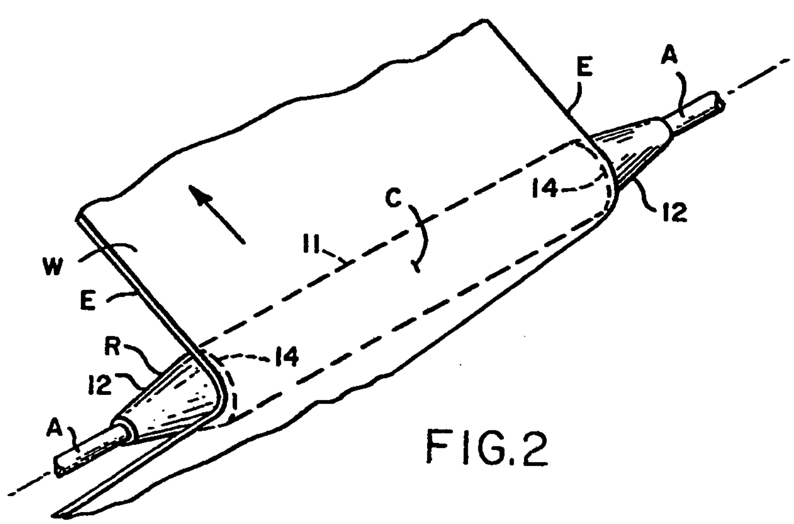

FIG.2

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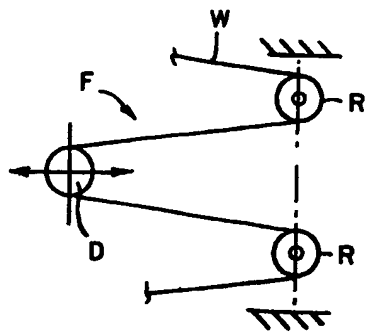

FIG. 1

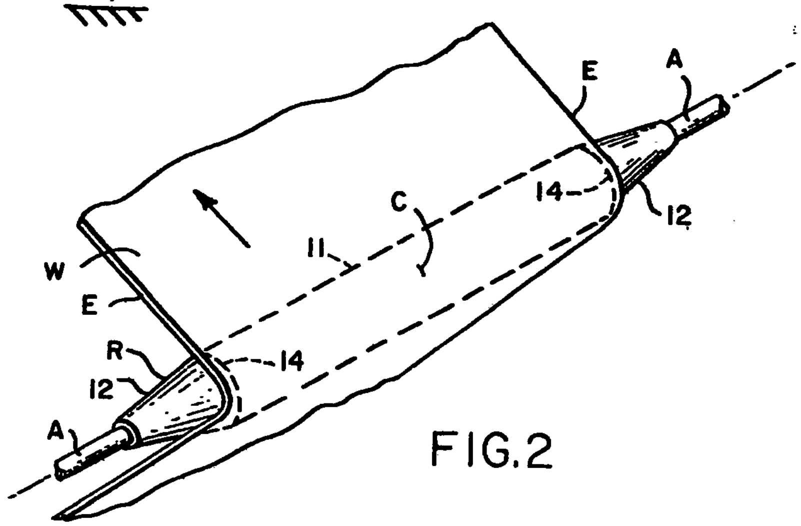

FIG. 2

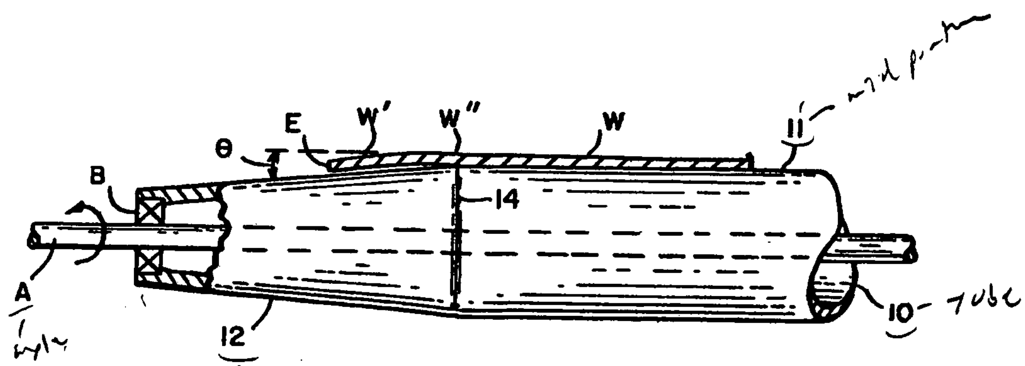

FIG. 3

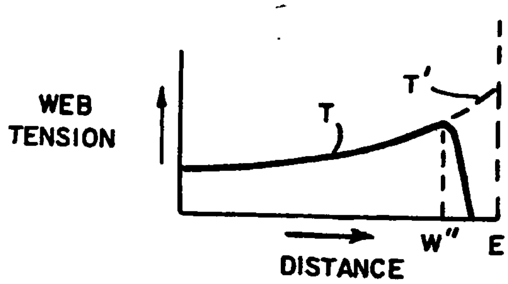

FIG. 4

SPECIFICATION

Method and means for relieving edge stress in a running web

This invention relates to improvements in web handling. It relates more particularly to a method and means for minimizing edge stress in a moving web.

When transporting web from a web supply to a web consuming machine such as a corrugator, the web is passed around various guide rollers to change its direction. For example, in a typical installation, web from a supply roll may travel through splicing apparatus which includes a festoon or web accumulator comprising fixed rollers and movable dancer rollers, the web being looped back and forth around these rollers so that a maximum amount of web storage may be provided in a minimum amount of space to facilitate splicing of the web. From the festoon, the web proceeds to the corrugator.

When web, particularly relatively brittle web, is run under tension at a relatively high speed, tears tend to form at the edges of the web. These tears, of course, weaken the web and may precipitate a web break which requires the line to the corrugator to be shut down. It is believed that this edge damage phenomenon is caused by stress concentrations at either of the opposite edges of the web due to excessive tension applied to the web edge by the guide rollers around which the web is trained. When running web a selected amount of tension (which may be as high as 25% of the tensile strength of the web) is imparted to the web by force-loading the festoon dancer rollers away from the fixed rollers so that the lateral position and speed of the web can be controlled along its course to the web consuming machine. The festoon rollers which actually apply the tension to the web are cylindrical across their entire lengths.

However, the web is not tensioned uniformly across its entire width for various reasons. Usually due to the small amount of available space, the guide rollers are small in diameter compared to their length and they are tubular with relatively thin walls to minimize their inertia and thereby to minimize web tension upsets during web speed changes. As a consequence, the rollers deflect appreciably under web tension so that the web path at the center of the web is appreciably shorter then the paths at the edges of the web. Thus when the web is drawn tight across the entire length of the roller, the stresses on the edges of the web are appreciably greater than those at the web center. Indeed such roller deflection of this character can cause effective web strength reduction by a factor of two or even more.

Additional tension increases at the web edges can arise because of misalignment of adjacent rollers which can easily cause a doubling of the tension level at one edge of the web as compared with the means web tension. Also, some rollers have resilient coverings to increase the coefficient of friction between the web and the roller which cover may deflect under tension. The deflection is substantially uniform over most of the roll surface. However, the transition from the deflected to the undeflected covering condition begins under the edge of the web. Resultantly, the web path at the very edge of the web is slightly longer than the path just inside the edge producing a stress concentration and thus a reduced apparent web breaking strength. Imperfections in the edges of the web also cause local stress concentrations whose effect is to precipitate tensile failure of the web at an average tension appreciably lower (i.e. by a factor of two to six or more) than its intrinsic tensile strength. All of these problems have tended to increase the incidence of edge tearing and web breakage particularly in wide span, relatively brittle webs such as kraft paper used in making corrugated board.

Accordingly, it is an object of the present invention to provide a technique for minimizing the incidence of edge tearing in a running web.

A further object of the invention is to provide a method of handling relatively wide, brittle webs so as to minimize stress concentrations at the edges of the web.

A further object of the invention is to provide apparatus for minimizing lengthwise tension at the edges of a running web whose direction is being changed.

Other objects will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more such steps with respect to each other and the apparatus embodying the features of construction, combination of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed description, and the scope of the invention will be indicated in the claims.

Briefly, instead of guiding a running web with rollers which are cylindrical along their entire lengths, the web is trained around rollers having a pronounced taper in the region underlying the opposite edges of the web. Furthermore, the peripheral boundaries between the cylindrical central surface portion of the roll and the tapered end surface portions thereof are gently rounded so as to minimize stress concentrations at those boundaries. The angle of taper is selected so that all web edge contact with the roller is lost within a very short distance from that junction between the cylindrical and tapered roller surfaces.

By contouring the roller thusly so as to relieve the tension at the edges of the web, the apparent breaking strength of the web can be increased to approximately the intrinsic tensile strength of the web thus greatly reducing the deleterious effects on the web of web edge tears, roller misalignment and deflection and resilient roller coverings discussed above.

It should be mentioned at this point that non-cylindrical guide rollers have been used heretofore to guide moving webs. For example, it is notoriously old to employ a crowned roller to help

center a web. However, that type of roller has a small taper and is invariable used with a web such as a conveyor belt that is laterally rigid. In fact, that rigidity is essential to the achievement of the centering action, as is the maintenance of contact between the web and roller across the full width of the web. If a crowned roller were used to guide a non-laterally rigid paper or cloth web of the type which which we are concerned here, the web material would simply bunch toward the center of the roller and be ruined. Indeed, in the present application it is essential that the web not experience any permanent effect from passing over the rollers.

It is also known to flare the ends of a guide roller over which paper web is run for the purpose of generating a transverse tension in the web to keep it running smoothly. However, the amount of taper is quite small (typically 0.0014 inch per roller foot) so that the web remains in full contact with the roller all the way out to its edge with only a very slight tension gradient in the web. Thus, as with the crowned roller used for web centering, it is necessary for the web to be in contact with the roller across its full width in order for the smoothening effect to occur.

In accordance with the present technique, on the other hand, the ends of the guide roller are relatively sharply tapered so that all contact between the web and the guide roller is lost within a very short distance of making the gradual transition from the cylindrical roller surface to the tapered surface. A typical taper to practice this invention is in the range of 0.1 to 0.25 inch per roller foot.

The configuration of each guide roller in this fashion minimizes tension at the opposite edges of the web and thus materially reduced the incidence of edge tears and web breaks and, in general, improves the runnability of the web.

Existing web handling apparatus can be retrofitted with tapered guide rollers of the type described herein relatively easily and the cost of such rollers should not be appreciably more than the cost of conventional completely cylindrical rollers. Therefore this technique should find wide application in the handling of webs, particularly wide, thin, relatively brittle ones.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of a web festoon employing guide rollers made in accordance with this invention;

FIG. 2 is a fragmentary perspective view on a larger scale showing a festoon guide roller in greater detail;

FIG. 3 is a fragmentary elevational view with parts in section, on a still larger scale, showing the FIG. 2 roller in still greater detail, and

FIG. 4 is a graph illustrating the beneficial effects achieved by the technique described herein.

Turning to FIG. 1 of the drawing, web W from a web source (not shown) is fed by way of a festoon F to a web consuming machine such as a corrugator (not shown). The festoon F includes a pair of stationary guide rollers R and a movable dancer roller D which is movable toward and away from rollers R. The dancer roller is force-loaded by conventional means (not shown) away from the fixed rollers so as to impart a selected tension to the web W. Of course, the festoon also accumulates a relatively long stretch of web so that web can proceed uninterruptedly to the web consuming machine in the event it becomes necessary to interrupt the supply of web, for example, to effect a web splice when a roll of web expires.

Each roller in the festoon F is specially shaped to minimize tension at the edges E of web W. One of the rollers, namely a roller R, is shown in detail in FIGS. 2 and 3 of the drawing. The roller R comprises a hollow aluminum tube 10 which is typically on the order of six inches in diameter at its center and eight or nine feet long. The central portion 11 of tube 10 is substantially cylindrical. However, the tube ends 12 are tapered at a relatively sharp angle θ with respect to the central portion of the tube. The transition from the cylindrical to the tapered shape takes place along a peripheral boundary or junction 14 which is itself gently rounded for reasons that will become apparent. Tube 10 is rotatively supported by way of end bearings B on an axle A mounted in appropriate supporting structure (not shown).

Each tapered end 12 of roller R is located so that it underlies the edge margin W' of the web W trained around that roller. The angle θ is selected so that all contact between the web and the roller R is lost within a very short distance outboard of the junction 14 on the roller, i.e. 1 to 3 inches. Typically the taper at the ends of roller R is in the order of 0.1 to 0.25 inch per foot. Thus, for example, a roller R having a face width of 90 inches would have tapered ends 12 which are 15 inches long, leaving a cylindrical midportion 11 which is 60 inches long. This taper would be effective for webs between 66 and 87 inches wide, the latter figure being the nominal maximum width for the particular machine. It should be emphasized that this taper is approximately 100 times larger than the taper employed in the conventional outwardly flaring rollers that are used to laterally tension web or in the crowned rollers that develop a self-centering action in a laterally rigid belt.

There is some elastic deflection or deformation of the portions W'' of the web which extend just beyond the cylindrical portion 11 of the roller. However, that deformation is minimized by employing the gradually rounded boundaries 14 between tube portion 11 and the tapered ends 12 which serve to support web portions W''. Thus the stress concentrations in the web in the regions of the boundaries 14 are minimized.

Referring now to FIG. 4, by running the web W under tension on a roller R having a cylindrical

midportion 11 and ends 12 which are relatively sharply tapered just inboard of the web edges E, the web tension indicated by curve T gradually increases from the center C of the web outward toward its edge E. However at the location of the roll junction 14 just inboard of the web edge, the tension drops off drastically and is essentially zero at a point intermediate between the junction and the edge of the web. Using a standard roller, the web tension continues to increase out to the very edge of the web as indicated by the dotted line T' in FIG. 4. Thus by reducing web edge tension in this fashion, the apparent breaking strength of the web is increased almost to the intrinsic tensile strength of the web enabling the web to better withstand the adverse effects of roller misalignment and deflection and edge tears which are a prime cause of web breaks.

It will thus be seen that the objects set forth above among those made apparent from the preceding description are efficiently attained, and since certain changes may be made in carrying out the above steps and in the construction set forth, it is intended that all matter contained in the above description or shown in the accompanying drawing be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described.

CLAIMS

1. A method of transporting a relatively wide laterally nonrigid running web comprising the steps of

A. forming a transport roller having a generally cylindrical central portion, relatively sharply tapered end portions and peripheral junctions between the cylindrical and tapered portions of the roller,

B. training around the roller a flexible laterally nonrigid web whose width is greater than the length of the cylindrical portion of the roller but less than the total face width of the roller so that the edges of the web extend only slightly beyond the cylindrical portion of the roller, and

C. advancing the web under tension in rotative centered engagement with the roller so that all contact between the web and the roller is lost within a very short distance beyond the ends of the cylindrical roller portion so as to relieve edge tension in the web.

2. The method defined in claim 1 wherein the roller is formed with end tapers of from 0.1 to 0.25 inch per foot.

3. The method defined in claim 1 and including the additional step of forming said peripheral junctions so that they are gently rounded.

4. A method of transporting a web as claimed in claim 1 substantially as described herein with reference to the accompanying drawings.

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